

Objective: Enhance resident physician management of pediatric DKA & improve patient safety.

- ❖ An attending of the appropriate admitting team (or the PALS) attending should be notified of all DKA admissions

Clinical Criteria for DKA: SBG > 200, urine/serum ketones, acidosis evidenced by pH < 7.3 & CO₂ < 15

- ❖ Mild DKA: pH 7.21 - 7.3 or CO₂ 11 - 15
- ❖ Moderate DKA: pH 7.11 - 7.2 or CO₂ 6- 10
- ❖ Severe DKA: pH < 7.1 or CO₂ < 5 or mental status changes

PICU Admission Criteria (one or more)

- ❖ Profound acidemia (pH < 7.1)
- ❖ Severe electrolyte disturbances (K⁺ < 2.5)
- ❖ Young age (< 2 years old)
- ❖ Profound shock
- ❖ Altered mental status
- ❖ Respiratory failure / Intubation
- ❖ Dysrhythmias
- ❖ Cerebral edema

1) First Hour Interventions [Check to see what has been done in the PED or at the outside hospital]

A) Labs

- i) Bedside POC (point of care) blood glucose, VBG, Chem10, iCal, UA, CBC with diff, HbA1c

B) Initial fluid resuscitation

- i) NS 10 - 20 mL/kg bolus

Give additional bolus(es) for hypotension or shock. Children with DKA not in shock should receive 1 or 2 normal saline boluses.

2) Inpatient Monitoring

A) Access & Monitors

- i) Place one large bore PIV
- ii) Cardiac monitor
- iii) q2 hour neuro checks
- iv)) Sips & chips; strict I/Os

(1) *Sips & chips should be ice & water only—for children with resolving acidosis (CO₂ >10). NPO only for children that are severely acidotic or not tolerating oral intake.*

(2) Consider PO or IV Zofran (ondansetron) for children with significant nausea or vomiting

B) Lab schedule

- i) q1 hour POC blood glucose → while on insulin drip

Send serum glucoses hourly to the lab if the glucometer reads "high".

- ii) If electrolyte disturbances, q4 hour Chem10 → change to q8 hour when pH ≥ 7.25 & electrolytes remain stable

- iii) Repeat VBG 12 hours after initial VBG in children with moderate to severe DKA

- iv)) q void UA (if admitted to the PICU) or q void POC urine dip (if admitted to Peds

Specialty Care Unit or when transferred to this unit)

v) For new diabetics: IA-2 antibodies, anti-GAD antibody, islet cell antibodies, insulin antibodies, TSH, FT₄, celiac disease reflex panel [gliadin IgA Ab; TTG IgA ab], C-peptide level, Insulin level

3) Initial Fluid Management [To be done simultaneously with Section 4 "The Insulin Drip"]

A) **Fluid rate** - assume 10% dehydration & replace this deficit over 48 hours

- i) If pt is in decompensated shock, bolus with NS 20 cc/kg upto 3 times, until BP stable – call PICU immediately

ii) Initial IVF rate should be 1.5 x MIVF

(1) $MIVF = [(100 \text{ mL/kg})(1^{\text{st}} 10 \text{ kg}) + (50 \text{ mL/kg})(2^{\text{nd}} 10 \text{ kg}) + (20 \text{ mL/kg})(\text{all remaining kg})] \div 24 \text{ hours}$

If the child has received > 2 NS boluses, still initiate IVF therapy at 1.5x MIVF, but call the appropriate admitting team (w)

- iii) Sample calculations - 7 year old ♀; 30 kg

(1) $MIVF = [(100)(10) + (50)(10) + (20)(10)] \div 24 \text{ hours} = 71 \text{ mL/hour}$

(2) $1.5x \text{ MIVF} = \{1.5 \times [(100)(10) + (50)(10) + (20)(10)]\} \div 24 \text{ hours} = 106 \text{ mL/hour}$

B) **Fluid composition**

- i) Be sure the patient's potassium is in the normal range & be sure the child has voided before adding potassium to the fluids

See "5 – Electrolyte Disturbances"

- ii) < 35 kg: Start with NS + 20 mEq KCl/L + 20 mEq/L KPhos (x)

(1) May substitute KAcetate for KCl to prevent hyperchloremic metabolic acidosis

- iii) ≥ 35 kg: Start with NS + 40 mEq KCl/L + 20 mEq/L KPhos (y)

(1) May substitute KAcetate for KCl to prevent hyperchloremic metabolic acidosis

- iv)) Be sure to order IVF containing dextrose at this time, as pharmacy must prepare these solutions

See "4 – The Insulin Drip" & "5 – Ongoing Fluid Management & Dextrose Guidelines"

4) The Insulin Drip [To be done simultaneously with Section 3 "Initial Fluid Management"]

- A) **Immediately order an insulin drip** infusion at 0.1 units/kg/hr, start after NS bolus and f/u POC glucose done.
- i) Do **NOT** give an initial IV or subcutaneous insulin bolus
 - ii) In a child with known diabetes, please give home Lantus (glargine) dose at time of admission, start insulin drip also, and **call Pediatric Endocrinology**
 - iii) In a child with an insulin pump, please disconnect the pump & **call Pediatric Endocrinology** for Lantus (insulin glargine) recommendations.
 - iv) In a new diabetic, give Lantus (insulin glargine) 0.2 U/kg at admission SQ. 2nd dose Lantus to be given 12 -24 hrs later. For < 8yo at next morning 0800, for >8yo at next bedtime.
 - v) Aim to have blood glucose level decrease by 50-100 mg %/hr.
 - vi) When blood glucose falls to < 250mg/dL Y-in add dextrose (D10 bag) to the IV solution to have an equivalent D5. When BG < 150, then change to D10NS to D10NS or 1/2 NS with electrolytes
 - vii) Unless a patient is truly hypoglycemic (<50), the insulin drip should not be decreased to less than 0.05u/kg/hr insulin is essential for preventing continued ketogenesis, IV insulin should not be discontinued until the HCO₃ is >17 mEq/L.

5) Ongoing Fluid Management & Dextrose Guidelines

Be aware that dextrose may fall very quickly in the first few hours. The goal correction is ≤ 100 mg/dL/hour; & titrating IVF—both dextrose-containing IVF & non-dextrose containing IVF—to maintain blood glucose between 130 – 200 mg/dL.

- A) After administering initial fluid resuscitation, check a POC glucose
- B) Add dextrose (D₁₀W) to IVF immediately if blood glucose falls more than 100 mg/dL/hour or as blood glucose approaches 300 mg/dL
- C)
 - i) IVF composition—**goal POC blood glucose 130 – 200 mg/dL**
 - (1) < 35 kg: Start with D₁₀W + NS + 20 mEq KCl/L + 20 mEq/L KPhos
 - (a) May substitute KAcetate for KCl to prevent hyperchloremic metabolic acidosis
 - (2) ≥ 35 kg: Start with D₁₀W + NS + 40 mEq KCl/L + 20 mEq/L KPhos
 - (a) May substitute KAcetate for KCl to prevent hyperchloremic metabolic acidosis
 - (b)
- D) POC blood glucose approaching 300 mg/dL should prompt an increase in glucose infusion rate (GIR) by:
 - i) Titrating IVF to increase dextrose; where the total fluid rate ("Section 3") remains at 1.5x – 2x MIVF
Titrating dextrose-containing & non-dextrose containing IVF should be based on clinical judgment; & the following examples are NOT meant to give exact numbers (or percentages %) for fluid rates but to show how IVF rates may increase/decrease with varying blood glucose values

(1)) Example #1: 7 year old ♀; 30 kg; received 1 NS bolus; normal K⁺; 2x MIVF = 142 mL/hr

Blood Glucose	D ₁₀ W + NS + 20 KCl + 20 KPhos	NS + 20 KCl + 20 KPhos	Total Fluid Rate (Constant; 2x MIVF)	Insulin Drip (0.1 U/kg/hr)
800	-	142	142	3 units/hour
300	71	71	142	3 units/hour
220	91	51	142	3 units/hour
130	142	-	142	3 units/hour

(2)) Example #2: 13 year old ♂; 50 kg; received 2 NS boluses; normal K⁺; 1.5x MIVF = 132 mL/hr

Blood Glucose	D ₁₀ W + NS + 20 KCl + 20 KPhos	NS + 20 KCl + 40 KPhos	Total Fluid Rate (Constant; 1.5x MIVF)	Insulin Drip (0.1 U/kg/hr)
800	-	132	132	5 units/hour
300	76	56	132	5 units/hour
220	100	32	132	5 units/hour
130	132	-	132	5 units/hour

E) Nurses may run both IVF therapies & the insulin drip through 1 PIV

6) Electrolyte Disturbances

- A) Total body K⁺ & P deficit, initial K⁺ often falsely elevated secondary to acidosis
 - i) If K⁺ > 5.5 → leave K⁺ out of IVF initially
 - ii) If K⁺ < 2.5 → will need more intensive intravenous K⁺ supplementation – *meets PICU admission criteria*
 - (1) Add K⁺ to IVF immediately
 - (2) Consider obtaining an EKG
- B) Initial serum Na⁺ is usually low secondary to osmolar dilution & should increase with therapy
 - i) Corrected Na⁺ = $([Na^+] + \text{glucose} - 100 \times 1.6) \div 100$

7) Cerebral Edema

- A) Highest cause of mortality in DKA--usually occurs within 4-12 hours of treatment initiation
 - B) Risk factors: bicarbonate administration, high initial serum BUN, severe hypocapnia or acidemia at presentation, persistent hyponatremia during IVF therapy, (*fluid overload [limited evidence]*)
 - C) Warning signs: altered mental status, headache, Cushing's triad ⁽²⁾, seizure, abnormal pupillary responses
- D) In high risk children, hypertonic saline should be immediately available if clinical signs develop
 - i) Hypertonic (3%) saline 5 - 10 mL/kg over 30 minutes [*Do NOT order without attending approval first!*]

8) Hypoglycemia

- A) Hypoglycemia is considered blood glucose ≤ 60 mg/dL
- B) Do not stop the insulin drip
 - i) Adjust the glucose infusion rate to maintain normal blood glucoses. Only in an emergency stop the insulin drip. See "5 – Ongoing Fluid Management & Dextrose Guidelines" for titration of IVF therapy
- C) If child is not NPO → give juice & recheck POC blood glucose in 15 minutes
- D) If child is NPO → bolus with dextrose (D₁₀W @ 5 mL/kg or D₂₅W @ 2 mL/kg) & adjust IVF therapy. See "Section 4 – Ongoing Fluid Management & Dextrose Guidelines"
- E) Stop the insulin drip if blood glucose < 40 mg/dL or child has altered mental status

9) Transition to Subcutaneous Insulin

- A) Convert to subcutaneous insulin when DKA resolves as evidenced by trace/small urine ketones or serum ketones cleared, CO₂ > 15, pH > 7.3, &/or closure of the anion gap
 - i) See *Peds Insulin (SubQ) PowerPlan* in UNMH PowerChart
 - (1)) POC blood glucose qAC, qHS, & 0200
 - (2)) Insulin lispro [carbohydrate correction]
 - (3)) Insulin lispro [sliding scale]
 - (4)) Insulin glargine—to be given at 2100
- B) Decide what subcutaneous regimen will be used to determine when the first dose is given - *Please perform the following calculations, **but do NOT start** a regimen without consulting Pediatric Endocrinology.*

- i) For example - 7 year old ♀; 30 kg
 - (1)) Total daily subcutaneous insulin dose 0.5 - 1 U/kg/day
Endocrine suggests 0.4 U/kg/day - Ex: $30 \times 0.4 \rightarrow 12$ U/day
 - (2)) Basal insulin dose = ½ total daily sub-Q regimen - Ex: $0.5 \times 12 \rightarrow$ Lantus 6 U at bedtime
 - (3)) Carbohydrate coverage = $450 \div$ total daily sub-Q insulin dose
Endocrine suggests 500 - Ex: $500 \div 12 \rightarrow 1$ unit of insulin Lispro for ever 42 g carbs ("1:42")
To be less aggressive - Ex: Lispro 1:50 carb ratio
 - (4)) Correction factor or Sliding Scale: "1800 rule": $1800 \div$ total daily sub-Q insulin dose
Endocrine suggests "1500 rule" - Ex: $1500 \div 12 = 125 \rightarrow 1$ unit of insulin will decrease blood glucose by 125 mg/dL; therefore, *to be less aggressive* ½ unit of insulin will decrease blood glucose by 60 mg/dL

For blood glucose (mg/dL)	Adjust insulin
71 -150	No adjustment
150 - 210	0.5 units insulin
211 - 270	1 unit insulin
271 - 330	1.5 units insulin

- c) Leave the insulin drip on for 30 minutes after the subcutaneous insulin is started. Please communicate this to the nursing staff.

10) Appendix

(W) 4L/M² calculations when concerned about excessive fluid resuscitation: 7 year old ♀; weight 30 kg; height 130 cm; she received 3 (three), 20 mL/kg NS boluses

Total IVF_{rate} (mL/hr) = Deficit + 24 hr Maintenance

Deficit = [(100 mL/kg) – bolus(es) in mL] ÷ 48 hours → [(100)(30) – (20)(30)] ÷ 48 hours [(3000) – (1800)] ÷ 48 hours → 25 mL/hour

24 Hour MIVF (as above) → 71 mL/hour

24 Hour fluid intake should NOT 4L/M² exceed to lower risk of cerebral edema Calculate M² = √{[height (cm) × weight (kg)] ÷ 3600}

→ √{[(130) × (30)] ÷ 3600} → 1.04

Total IVF_{rate} (mL/hr) = Deficit + 24 hr Maintenance → (25 mL/hour) + (71 mL/hour) → 96 mL/hour

Therefore, at 96 mL/hour the child will receive 2,304 mL in 24 hours (= 96 mL/hr × 24 hr); and the child should NOT receive any more than 4,160 mL (= 4L × 1.04 M²) of fluid in 24 hours

Sample table for 4L/M² calculations based on 50th% for weight (kg) & 50th% for height (cm) in girls & boys

Girls					
Age (yr)	Weight (kg)	Height (cm)	4L/M ²	Maximum Fluid in 24 Hrs (mL)	24 hr Fluid Limit After 2 NS Boluses
2	12	85	2.13	2,129	1,649
3	14	94	2.42	2,418	1,858
4	16	101	2.68	2,680	2,040
5	18	108	2.94	2,939	2,219
6	20	115	3.20	3,197	2,397
7	23	122	3.53	3,531	2,611
8	26	128	3.85	3,846	2,806
9	29	133	4.14	4,140	2,980
10	33	138	4.50	4,499	3,179
11	37	144	4.87	4,866	3,386
12	42	151	5.31	5,309	3,629
13	46	157	5.67	5,665	3,825
14	50	161	5.98	5,981	3,981
15	52	162	6.12	6,119	4,039
16	54	163	6.25	6,255	4,095
17	55	163	6.31	6,312	4,112
18	56	163	6.37	6,369	4,129
Boys					
Age (yr)	Weight (kg)	Height (cm)	4L/M ²	Maximum Fluid in 24 Hrs (mL)	24 hr Fluid Limit After 2 NS Boluses
2	13	87	2.24	2,242	1,722
3	14	95	2.43	2,431	1,871
4	16	102	2.69	2,693	2,053
5	18	109	2.95	2,953	2,233
6	21	115	3.28	3,276	2,436
7	23	122	3.53	3,531	2,611
8	26	128	3.85	3,846	2,806
9	29	133	4.14	4,140	2,980
10	32	139	4.45	4,446	3,166
11	36	143	4.78	4,783	3,343
12	40	149	5.15	5,147	3,547
13	45	156	5.59	5,586	3,786
14	51	164	6.10	6,097	4,057
15	56	170	6.50	6,505	4,265
16	61	174	6.87	6,868	4,428
17	65	175	7.11	7,110	4,510
18	67	176	7.24	7,239	4,559

(X) 20 mEq /L KPhos =13.6 mmol Phos /L and 20 mEq K mmol Phos

(Y) 40 mEq/L KCL+ 20 mEq KPhos = 60 mEq K and 13.6

(Z) Cushing's triad: 1) hypertension; 2) bradycardia; 3) irregular respirations